

BSM Higgs searches at the Tevatron

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on behalf of the CDF and D0 collaborations



Outline and Introduction

- Description of current status of searches for Higgs Bosons in different frameworks BSM
 - Emphasize the results, no time for theory motivation
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- The combination of small signals, difficult backgrounds and sophisticated triggers makes these searches complicated
 - As you'll see: broad program in both CDF and D0

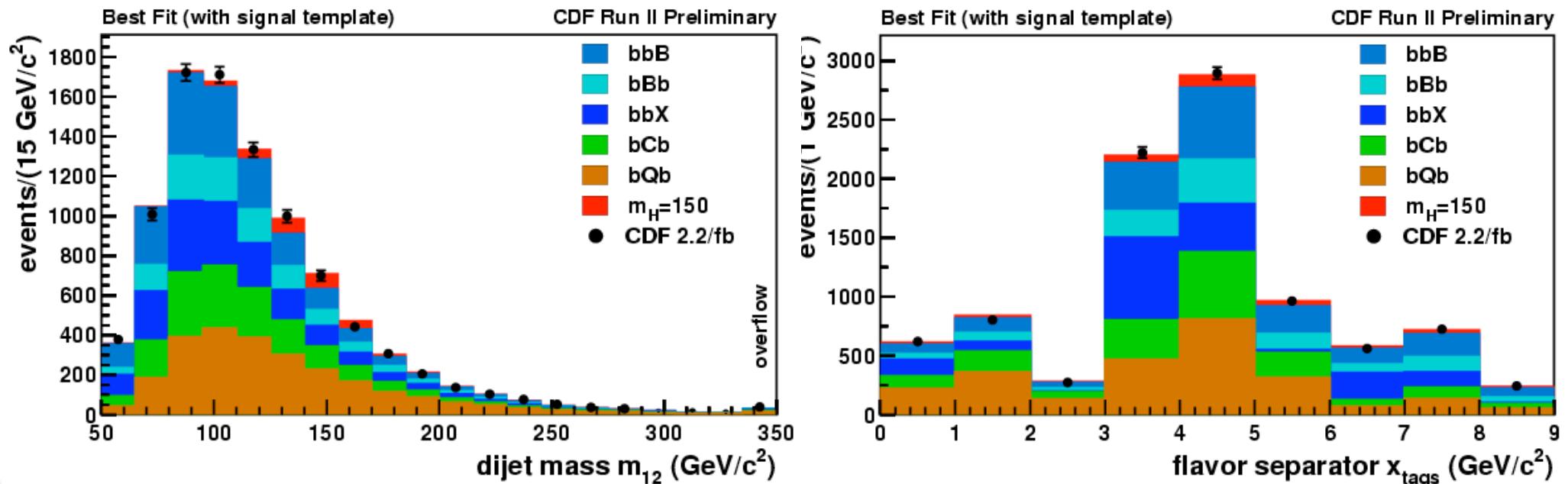




B-jet signatures: 3b-jets

**NEW
2.2 fb⁻¹**

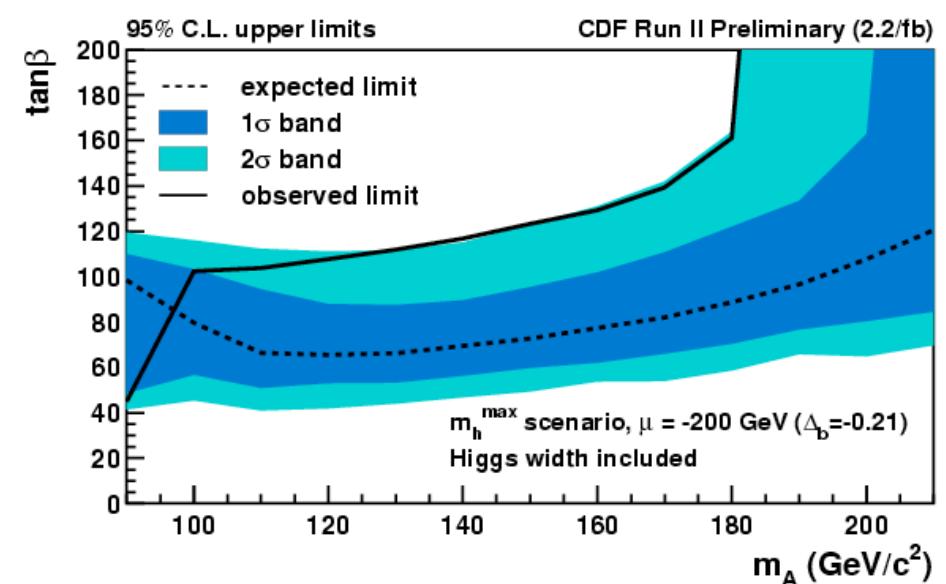
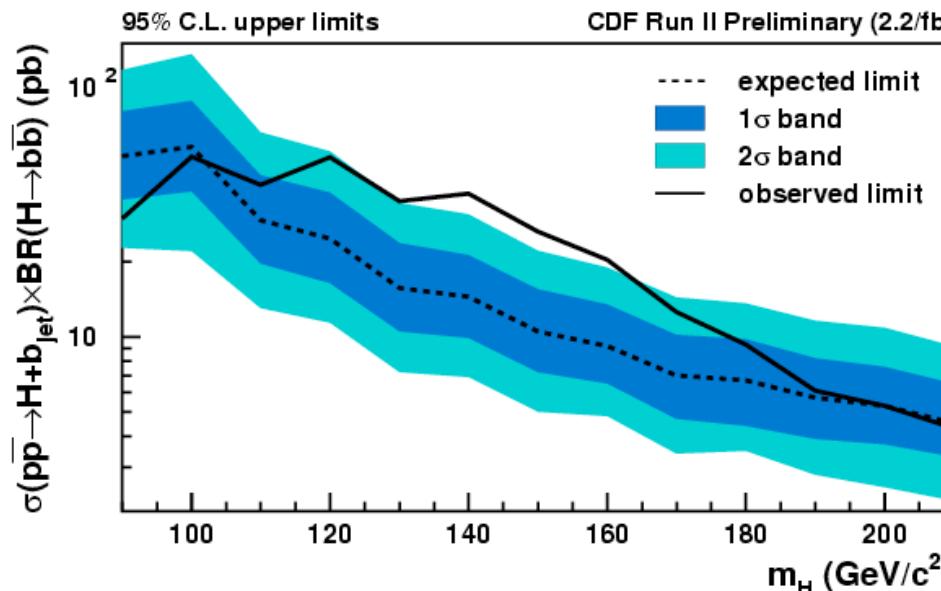
- Look for **exclusive production** of $bb \rightarrow \phi(bb) \rightarrow bb(bb)$
- Select candidate events compatible with **3 jets** identified as originating from a **b-quark**
- Estimate **QCD multijet background** from 2 b-jet sample
- Build discriminant variable for signal/background separation:
 - dijet mass spectrum vs tag mass difference, **m_{12} vs x_{tags}**
- Perform a fit using the **CL_s method** to extract signal and set exclusion limits
- Scan different masses and translate **limits to MSSM** scenarios





B-jet signatures: 3b-jets

- Limit calculation is done with **MCLIMIT** package, using CL_s method
- **Pseudoexperiments** are generated from the background-only fit
- **Shape systematics** are incorporated in the pseudoexperiments, interpolating histograms
- Results are obtained for width-less (narrow) Higgs. Corrections and width considered when doing Scenario interpretation

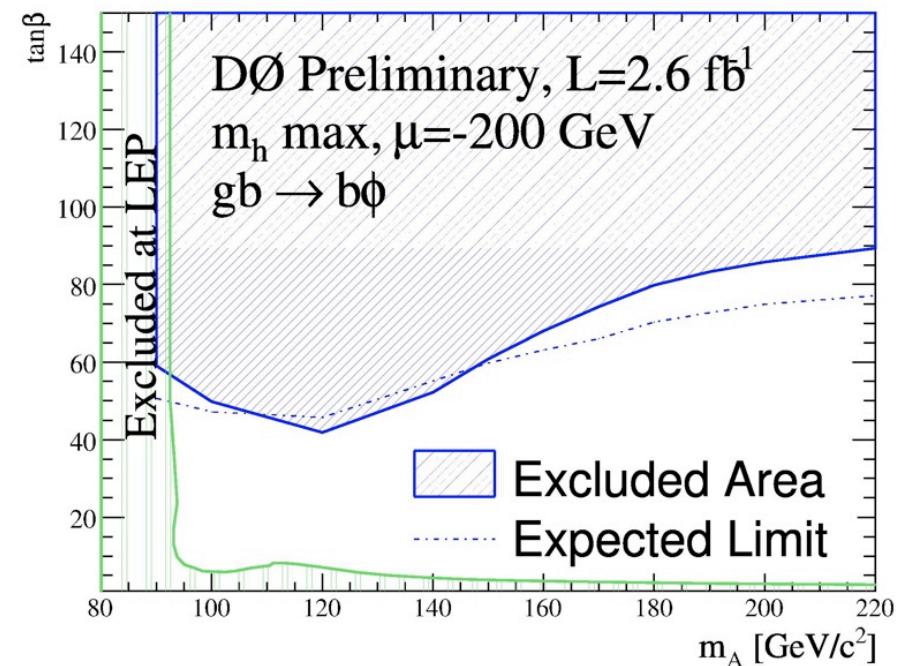
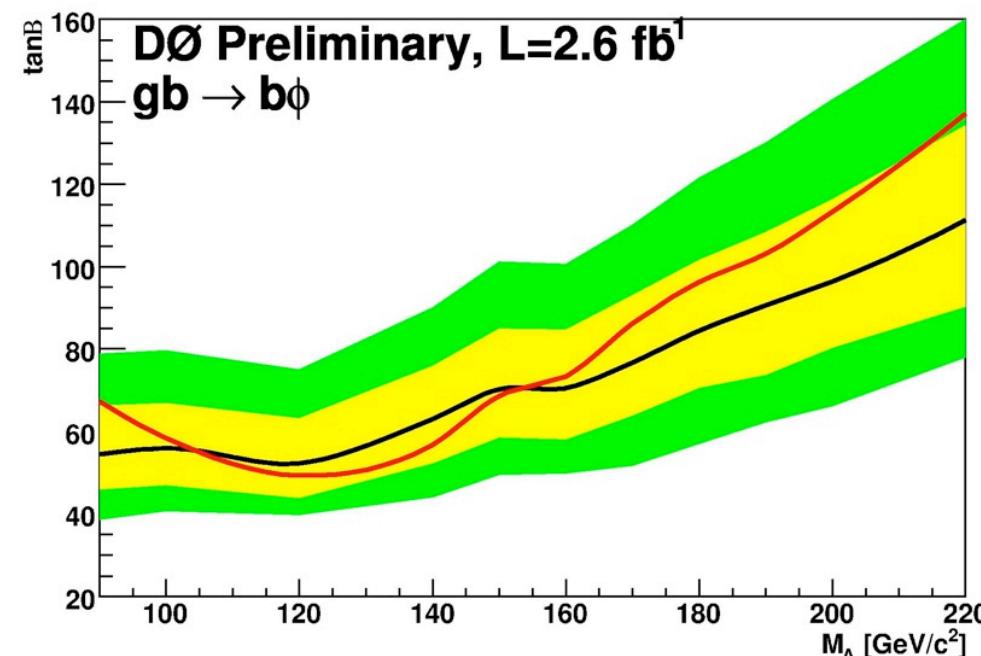




B-jet signatures: 3b-jets

2.6 fb⁻¹

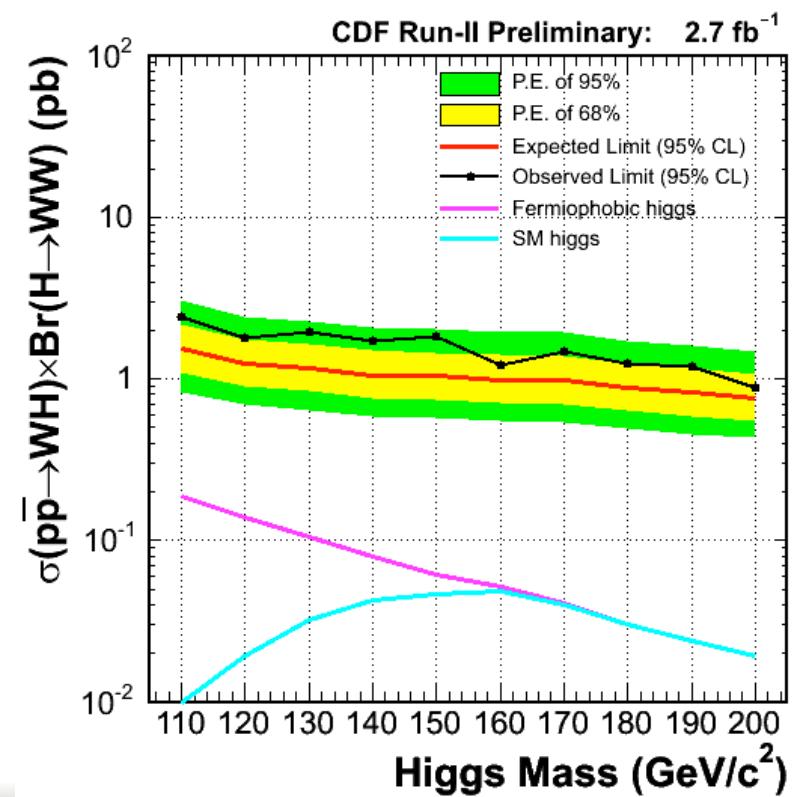
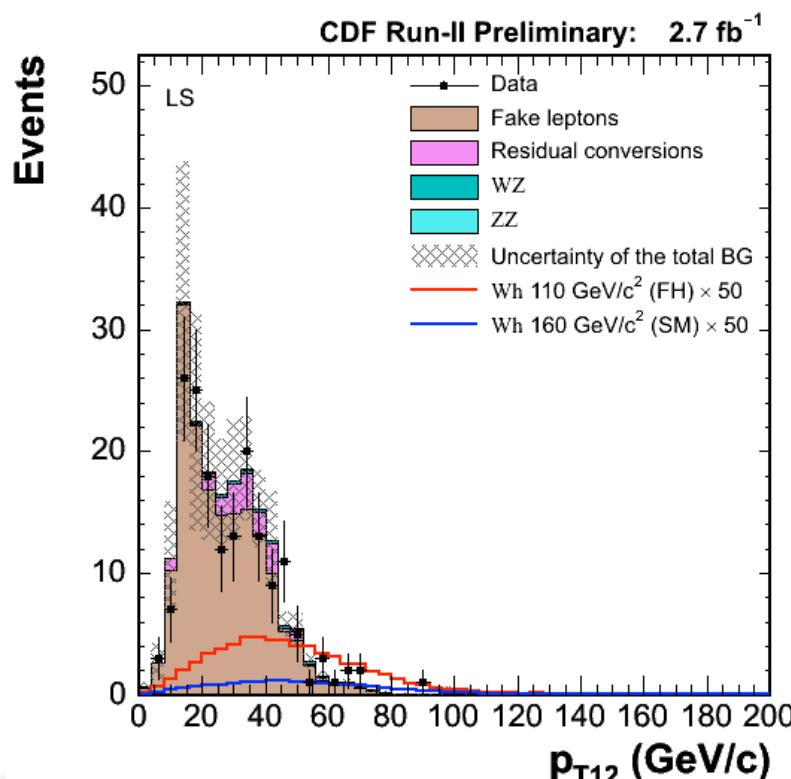
- **Combination** of two results: **RunIa** with 1.1 fb⁻¹ and **RunIb** with 1.5 fb⁻¹
- Event **selection**: ≥ 3 and ≤ 5 jets, ≥ 3 b-tags (NN based tagger)
- Signal/Background discrimination: **likelihood** based
- Background estimation: **shapes** from data, MC **scale factors**
- Limits: **CLs** method, and interpreted with FEYNHIGGS



Same-sign dileptons: fermiophobic Higgs

2.7 fb^{-1}

- **Neutral higgs** production associated with the W boson using **high- p_T isolated like-sign dilepton** events
- Fermiophobic Higgs: sensitivity at low mass with WW decay
- Event **selection**: leading lepton $p_T > 20 \text{ GeV}$, second lepton $p_T > 6 \text{ GeV}$
- **Backgrounds**: dibosons (MC), conversions, fake leptons
- **Signal** extraction: boosted decision tree. **Limits**: bayesian approach

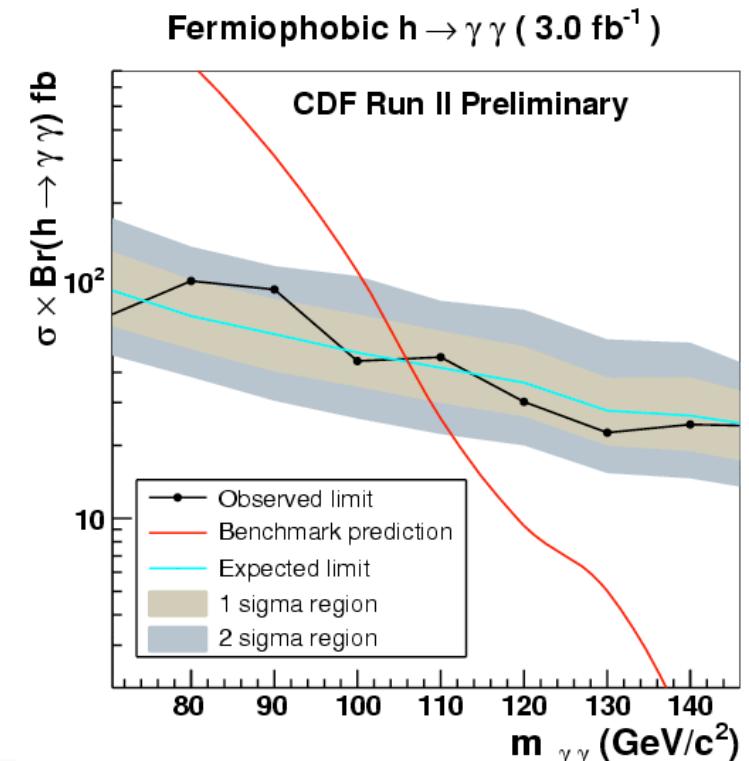
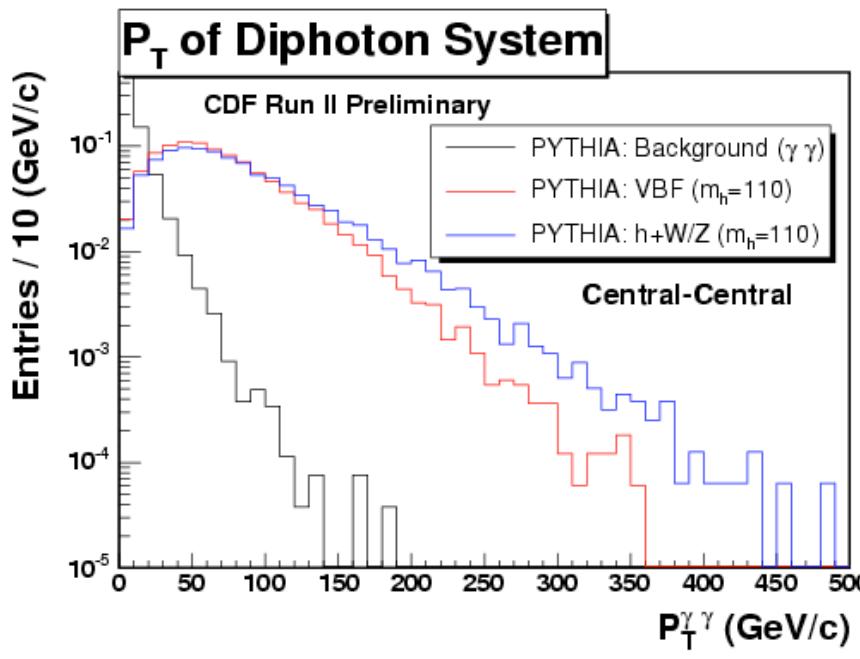


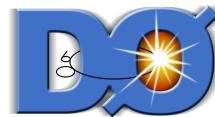


Fermiophobic Higgs: di-photon

3.0 fb^{-1}

- SM **branching fraction** 0.2%.
 - If no couplings to fermions, BR > 50% up to Higgs mass of 100GeV
- Pythia (standard CDF tunes, PDFs, ...) used to generate signal templates
- **Event selection** required two photons with $\text{ET} > 15 \text{ GeV}$
 - at least one central photon, no more than one plug photon
 - large invariant mass of the diphoton system $M > 30 \text{ GeV}$
- Profiled bin likelihood to extract signal

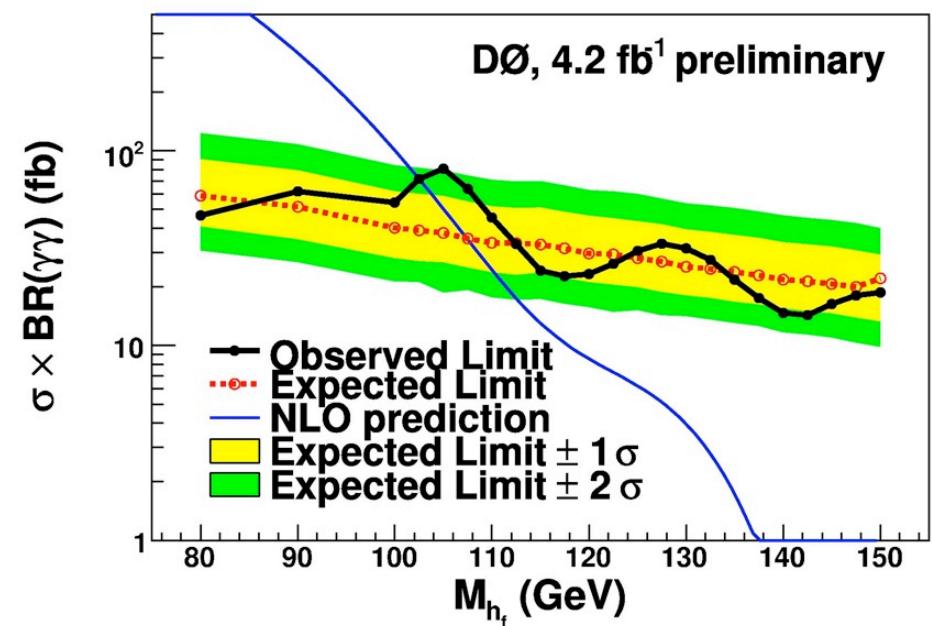
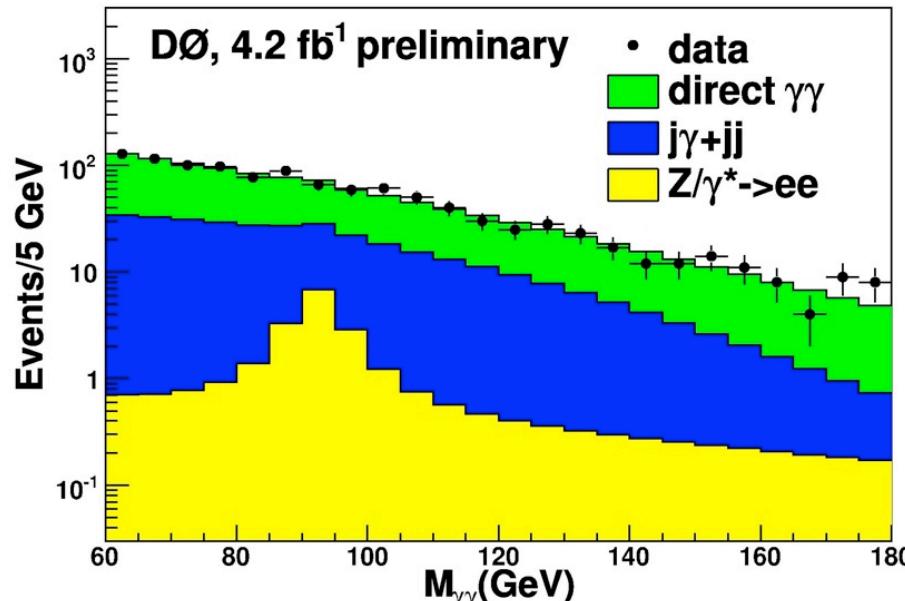




Fermiophobic Higgs: di-photon

4.2 fb^{-1}

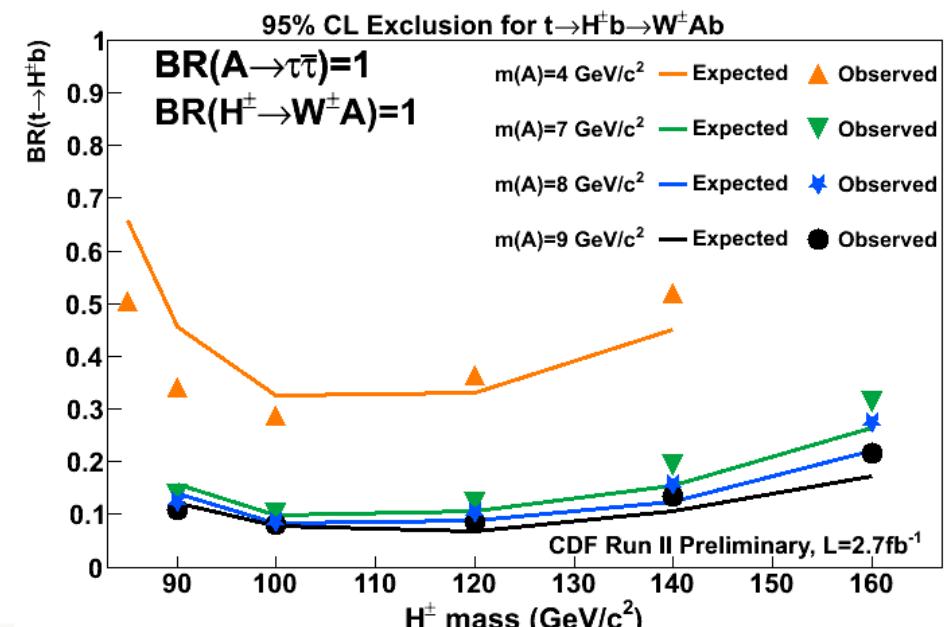
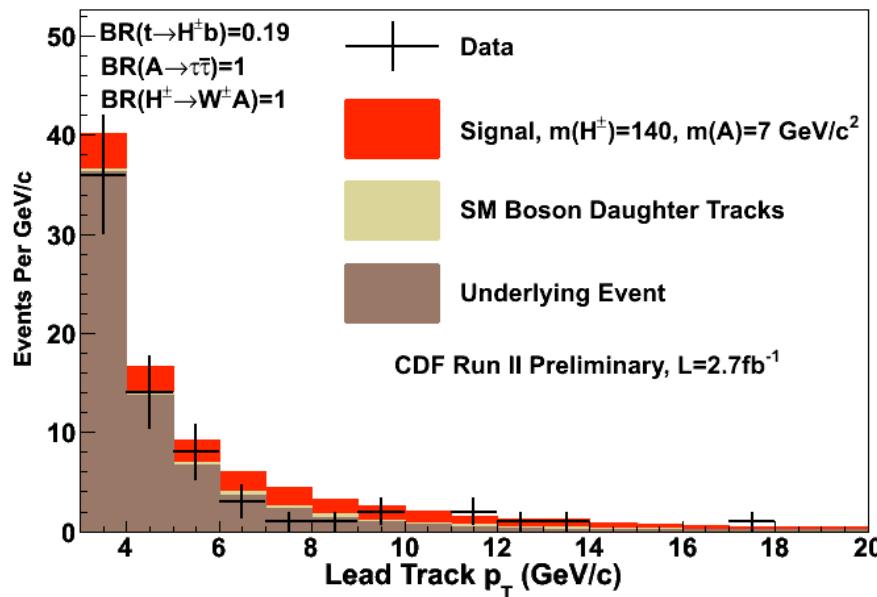
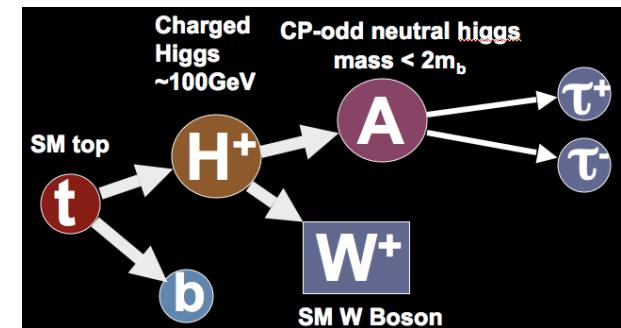
- Event selection: ≥ 2 central photon candidates
- Backgrounds:**
 - Drell-Yan (Pythia),
 - gamma+jets and dijets (fake matrix) and
 - gamma prompt production (side bands in diphoton bands)
- Limits obtained with the **CLs method**



nMSSM light Higgs in the top sample

2.7 fb^{-1}

- Search for light **pseudoscalar Higgs**: $m_A < 2m_b$
- Signature: **top pair** (lepton+jet selection) + 2 taus
 - Taus identified as **isolated tracks**
 - ≥ 3 jets, ≥ 1 b-jet, ≥ 1 lepton, **≥ 1 track**
- Most important **background**: Underlying Event
 - modeled from data: in Z and QCD events

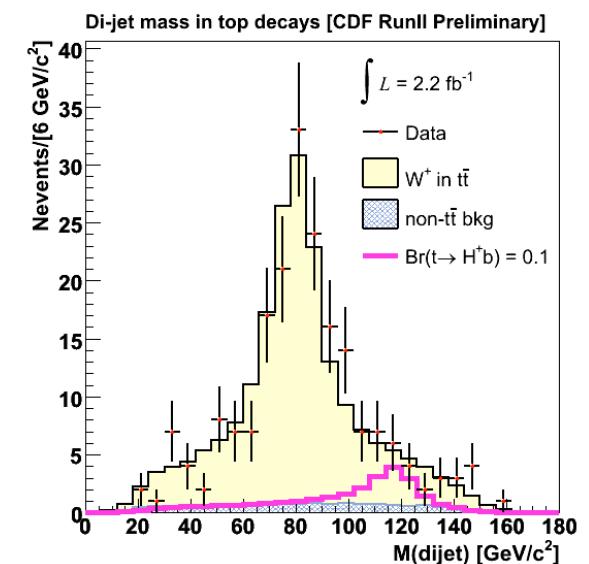
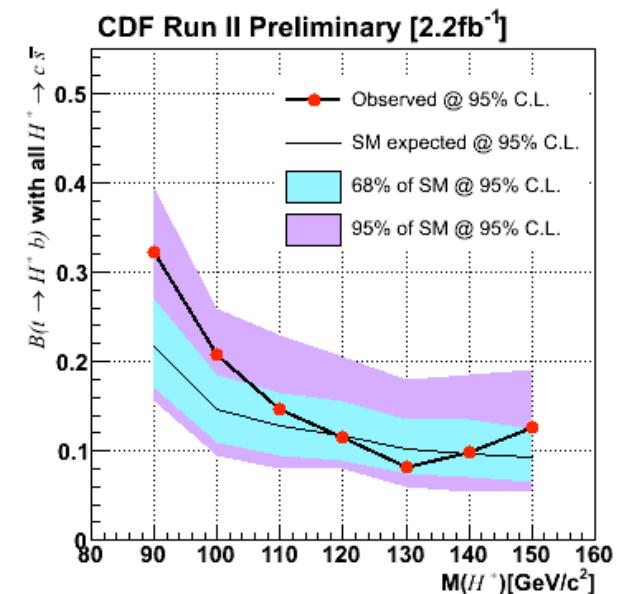
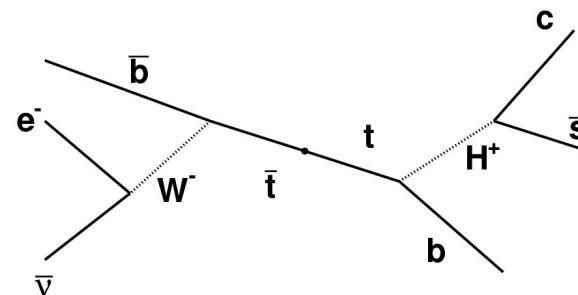


Charged Higgs in top decays

2.2 fb⁻¹



- Search in the **top pair** sample
 - a top quark decays to a charged Higgs
- viable at **low tan β** , around 1
- Event **selection**:
 - one high p_T lepton, large ETmiss
 - ≥ 4 central jets, ≥ 2 b-tags
- Used same techniques as for **top-pair cross section** measurement.
- **Binned likelihood** fit to di-jet mass to extract signal and set limits



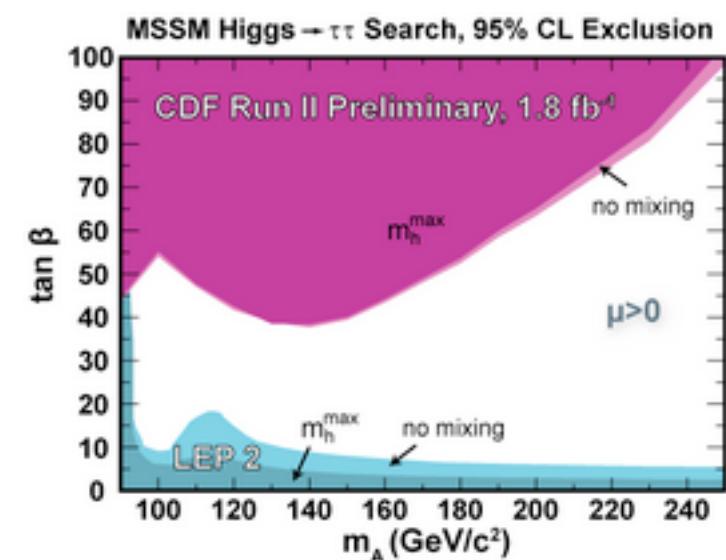
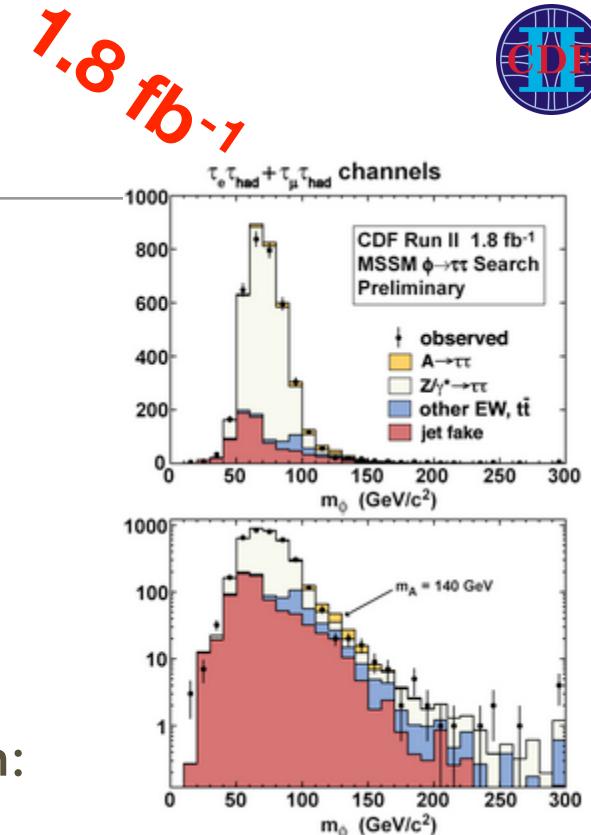
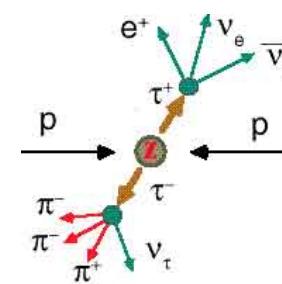
Neutral MSSM Higgs to ditaus



- **Three different channels**, with overall 50%:
 - hadronic tau + electron, muon (2 time 23%)
 - electron + muon (3%)

- **Backgrounds**:
 - Z, Drell-Yan, dibosons, top pairs, W: MC
 - QCD: fakes measured in data

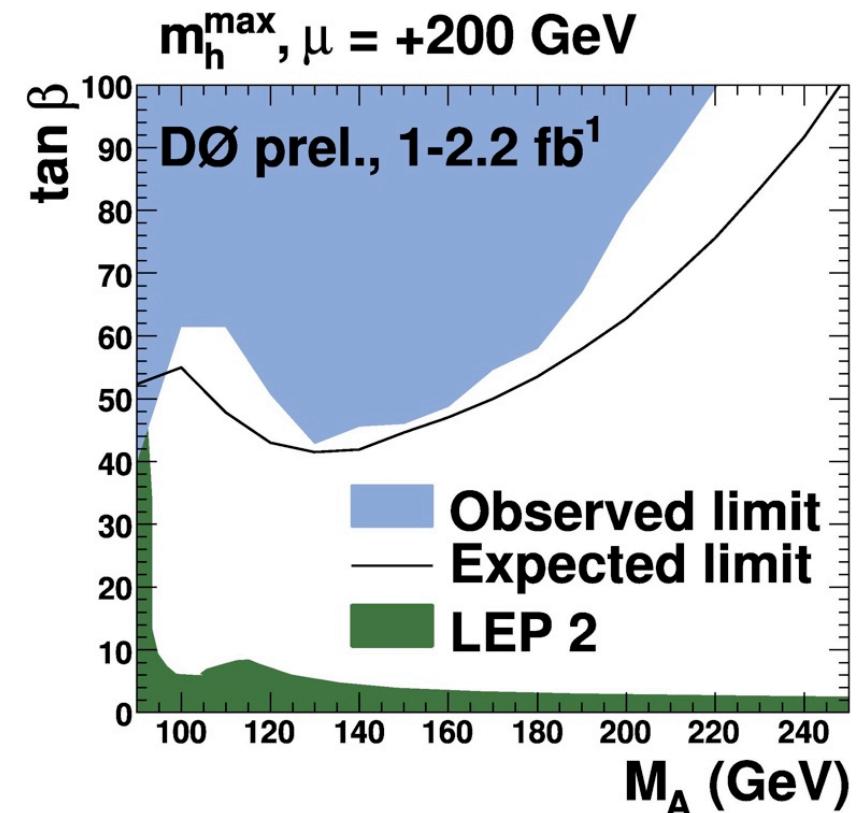
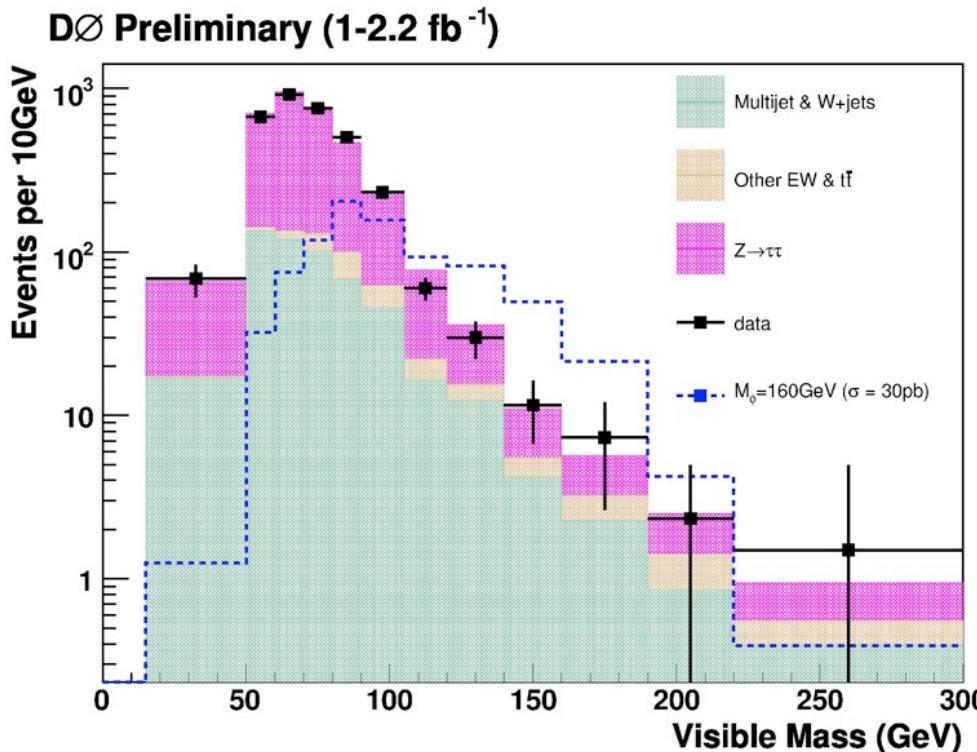
- Discriminant variable for signal/background separation:
 - **visible mass**, m_{vis}
- Perform a **profile likelihood fit** to extract signal
 - and set exclusion limits
- Scan different masses and translate limits to
 - **MSSM scenarios**



Neutral MSSM Higgs ditau combination

2.2 fb⁻¹, 

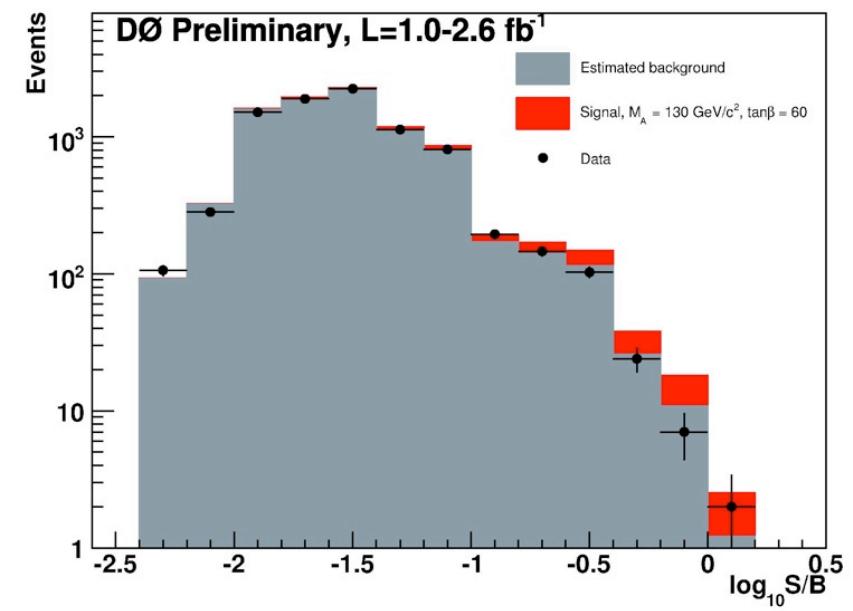
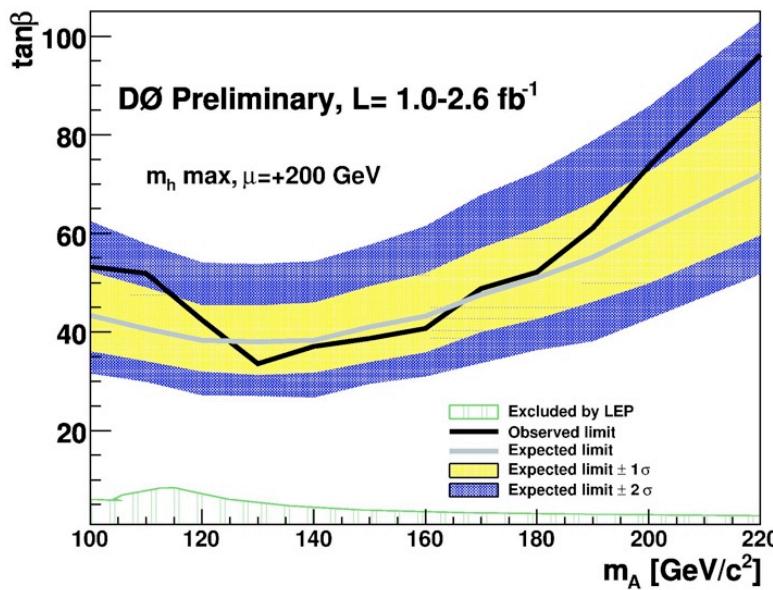
- Combination of the different ditau analysis:
 - RunIa: 1.0 fb⁻¹ hadronic tau + electron/muon, electron + muon
 - RunIIB: 1.2 fb⁻¹ hadronic tau +muon, electron + muon
- As in single channel searches, visible mass used as discriminator



MSSM Neutral Higgs searches combination

2.6 fb^{-1} , 

- Combines b-jet and tau final states
 - additional new channel: b + ditau (muon + tau) final state
- Combination done with the modified frequentist approach (CLs)



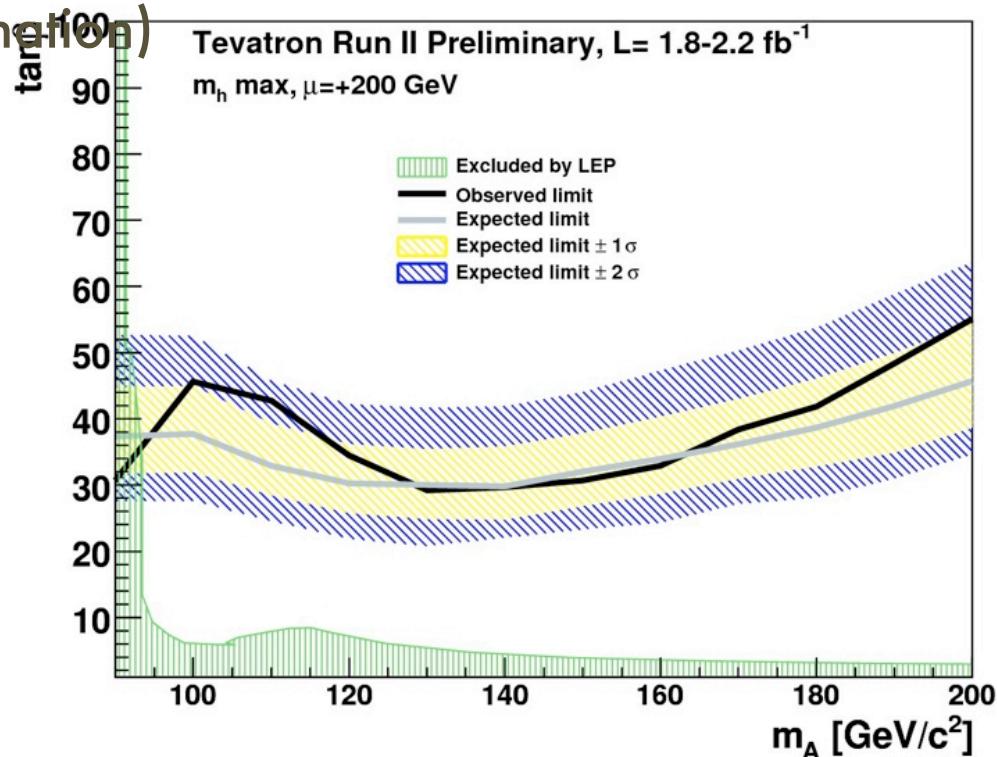
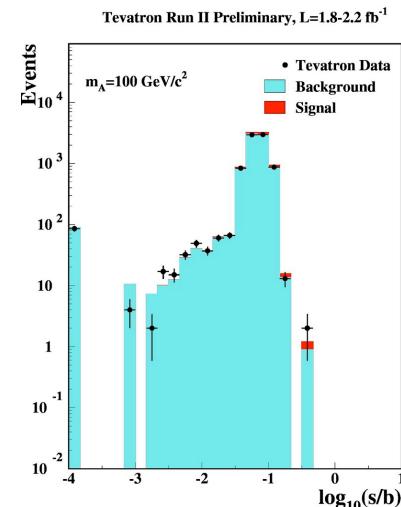


Tevatron MSSM Higgs to ditau combination

2.2 fb^{-1}

- **Combination** of all neutral MSSM Higgs boson searches to tau tau final state in the Tevatron
- Same **techniques** as for SM searches
- Two statistical methods were used:
 - **bayesian** approach (like CDF combination)
 - modified frequentist (like D0 combination)
- Results are similar:
within 10% for each mass point

	CDF	D0
$\tau_e + \tau_h$	1.8 fb^{-1}	1.0 fb^{-1}
$\tau_\mu + \tau_h$	1.8 fb^{-1}	$1.0 + 1.2$
$\tau_e + \tau_\mu$	1.8 fb^{-1}	1.0 fb^{-1}



Conclusions

- **Active and diverse program** of BSM Higgs searches
- Expect to combine all Tevatron results soon
- **Difficult** searches:
 - very small signals
 - difficult backgrounds
- Updates under way in most channels
- With more than 8 fb of data on tape, the **Tevatron still has a lot to say**

backup